

**CLAIMS**

I claim:

1. A method comprising the step of:

contacting a fluid including noxious sulfur-containing species with an effective amount of a sulfur scavenging composition comprising substantially monomeric aldehyde-amine adducts of a molar excess of at least one aldehyde or aldehyde donor with at least one amine having at least one sterically bulk substituent.

2. The method of claim 1, wherein the adducts are characterized by compounds of formulas (I), (II) or mixtures thereof:



where R is a hydrogen atom (H) or a carbon-containing group, R<sup>1</sup> and R<sup>2</sup> are the same or different, at least one being a sterically hindered carbon-containing group having between 3 and about 24 carbon atoms or R<sup>1</sup> and R<sup>2</sup> can form a ring system, R<sup>3</sup> is a divalent sterically hindered carbon-containing group, R<sup>4</sup> and R<sup>5</sup> are the same or different and are H or a CH<sub>2</sub>R group and where one or more of the carbon atoms of R, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> or mixtures thereof can be replaced by oxygen atoms in the form of ether moieties, nitrogen groups in the form of tertiary amine or amide moieties or mixtures thereof, and where one or more hydrogen atoms of R, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> or mixtures thereof can be replaced by fluorine atoms, chlorine atoms or mixtures thereof.

where the effective amount is sufficient to reduce, to reduce below a target level or to substantially eliminate the noxious sulfur-containing species in the fluid.

3. The method of claim 2, wherein R<sup>1</sup> and R<sup>2</sup> are the same or different sterically hindered carbon-containing groups.

4. The method of claim 2, wherein R is H.

5. The method of claim 2, wherein R is selected from the group an alkyl group, an aryl group, an alkaryl group, an aralkyl group and mixtures or combinations thereof.

1       6.     The method of claim 2, wherein R is H and R<sup>1</sup> and R<sup>2</sup> are the same or different and are  
2     selected from the group consisting of methyl, ethyl, propyl, isopropyl, butyl, isobutyl, pentyl,  
3     isopentyl, neopentyl, adamanyl, phenyl, benzyl, cyclopentyl, cyclohexyl, tetramethylamino bis-propyl  
4     ((CH<sub>3</sub>)<sub>2</sub>NCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>), derived from bis(4-aminocyclohexyl)methane, derived from bis(4-  
5     aminophenyl)methane, derived from 1,8-diazabicyclo[5.4.0]undec-7-ene, derived from  
6     bispicoylamine and mixtures or combinations thereof.

1       7.     The method of claim 1, wherein the composition comprises a solution including from about  
2     5 wt.% to about 50 wt.% of the adducts the remainder being a solvent.

1       8.     The method of claim 1, wherein the fluid comprises an inverted mud or drilling fluid.

1       9.     The method of claim 1, wherein the fluid is selected from the group consisting of an  
2     overbalanced inverted drilling fluid, a weighted inverted drilling fluid, and an underbalanced  
3     inverted drilling fluid.

1       10.    The method of claim 1, wherein the fluid comprises a processed fluid from refinery or a gas  
2     production facility.

1       11.    The method of claim 1, wherein the processed fluid is selected from the group consisting of  
2     gasoline, kerosene, jet fuels, diesels, stabilized condensates, and LPG.

1       12.    The method of claim 1, wherein the fluid is crude oil or condensate from oil/gas production.

1       13.    The method of claim 1, wherein the fluid is selected from the group consisting of a heavy oil  
2     fraction from recovery of bitumens, a processed mined oil, a process mined extract, bunker C and  
3     a heavy fuel.

1       14.    The method of claim 1, wherein fluid comprises lubricating oil.

1       15. The method of claim 1, wherein the fluid comprises an oil completion fluid.

1       16. The method of claim 1, wherein the fluid comprises a packer fluid.

1       17. The method of claim 1, wherein the fluid is selected from the group consisting of a storage  
2       fluid and a pickling fluid.

1       18. A method comprising the step of:

2             adding, to a fluid including noxious sulfur-containing compounds, an effective amount of a  
3             sulfur scavenging composition comprising substantially monomeric aldehyde-amine adducts of a  
4             molar excess of at least one aldehyde or aldehyde donor with at least one amine having at least one  
5             sterically bulk substituent.

1       19. The method of claim 18, wherein the adducts are characterized by compounds of formulas  
2       (I), (II) or mixtures thereof:



5             where R is a hydrogen atom (H) or a carbon-containing group, R<sup>1</sup> and R<sup>2</sup> are the same or  
6             different, at least one being a sterically hindered carbon-containing group having between  
7             about 3 and about 24 carbon atoms or R<sup>1</sup> and R<sup>2</sup> can form a ring system, R<sup>3</sup> is a divalent  
8             sterically hindered carbon-containing group, R<sup>4</sup> and R<sup>5</sup> are the same or different and are H or  
9             a CH<sub>2</sub>R group and where one or more of the carbon atoms of R, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> or mixtures  
10           thereof can be replaced by oxygen atoms in the form of ether moieties, nitrogen groups in the  
11           form of tertiary amine or amide moieties or mixtures thereof, and where one or more  
12           hydrogen atoms of R, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> or mixtures thereof can be replaced by fluorine  
13           atoms, chlorine atoms or mixtures thereof,

14             where the effective amount is sufficient to reduce, to reduce below a target level or to  
15             substantially eliminate the noxious sulfur-containing species in the fluid.

1       20. The method of claim 18, wherein the adding step is a continuous adding step, where the fluid  
2       is a fluid stream and the amount is sufficient to reduce, to reduce below a target level or to

3 substantially eliminate the noxious sulfur-containing species in the fluid on a continuous basis.

1 21. The method of claim 18, wherein the adding step is an intermittent adding step, where the  
2 fluid is a fluid stream and the amount is sufficient to reduce, to reduce below a target level or to  
3 substantially eliminate the noxious sulfur-containing species in the fluid on an intermittent basis.

1 22. The method of claim 18, adding step is a periodic adding step, where the fluid is a fluid  
2 stream and the amount is sufficient to reduce, to reduce below a target level or to substantially  
3 eliminate the noxious sulfur-containing species in the fluid on a periodic basis.

1 23. The method of claim 19, wherein R<sup>1</sup> and R<sup>2</sup> are the same or different sterically hindered  
2 carbon-containing groups.

1 24. The method of claim 19, wherein R is H.

1 25. The method of claim 19, wherein R is selected from the group an alkyl group, an aryl group,  
2 an alkaryl group, an aralkyl group and mixtures or combinations thereof.

1 26. The method of claim 19, wherein R is H and R<sup>1</sup> and R<sup>2</sup> are the same or different and are  
2 selected from the group consisting of methyl, ethyl, propyl, isopropyl, butyl, isobutyl, pentyl,  
3 isopentyl, neopentyl, adamanyl, phenyl, benzyl, cyclopentyl, cyclohexyl, tetramethylamino bis-propyl  
4 ((CH<sub>3</sub>)<sub>2</sub>NCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>), derived from bis(4-aminocyclohexyl)methane, derived from bis(4-  
5 aminophenyl)methane, derived from 1,8-diazabicyclo[5.4.0]undec-7-ene, derived from  
6 bispicoylamine and mixtures or combinations thereof.

1 27. The method of claim 18, wherein the composition comprises a solution including from about  
2 5 wt.% to about 50 wt.% of the adducts the remainder being a solvent.

1 28. A method comprising the step of:  
2 adding a fluid into a container;  
3 adding, prior to, after or concurrently, an effective amount of a sulfur scavenging

4 composition comprising substantially monomeric aldehyde-amine adducts of a molar excess of at  
5 least one aldehyde or aldehyde donor with at least one amine having at least one sterically bulk  
6 substituent,

7 where amount is sufficient to reduce, reduce below a target level or substantially eliminating  
8 noxious sulfur-containing species in fluid.

1 29. The method of claim 28, wherein the container is selected from the group consisting of a  
2 tank, a tanker, a pipeline, a barge, a floating platform, and a ship.

1 30. The method of claim 28, wherein the composition comprises a solution including from about  
2 5 wt.% to about 50 wt.% of the adducts the remainder being a solvent.

1 31. A method comprising the step of:

2 introducing into a downhole fluid an effective amount of a sulfur scavenging composition  
3 comprising substantially monomeric aldehyde-amine adducts of a molar excess of at least one  
4 aldehyde or aldehyde donor with at least one amine having at least one sterically bulk substituent,

5 where amount is sufficient to reduce, reduce below a target level or substantially eliminating  
6 noxious sulfur-containing species in fluid.

1 32. The method of claim 31, wherein the introduction is via a chemical tool, coiled tubing, or  
2 capillary coiled tubing (CCT).

1 33. The method of claim 31, wherein the introduction comprises squeezing.

1 34. The method of claim 31, wherein the introducing step is a batch introducing step.

1 35. The method of claim 31, wherein the composition comprises a solution including from about  
2 5 wt.% to about 50 wt.% of the adducts the remainder being a solvent.

1 36. A method for making a sulfur scavenger comprising the steps of:

2 contacting a molar excess of an aldehyde or aldehyde donor with an amine including at least

3       one sterically bulk substituent at a temperature and for a time sufficient to form a substantially  
4       monomeric aldehyde-amine adduct.

1       37.      The method of claim 36, further comprising the step of:  
2                  maintaining the adduct at a temperature sufficient to convert excess aldehyde or aldehyde  
3                  donor into innocuous compounds.

1       38.      The method of claim 36, further comprising the step of:  
2                  distilling the adduct to form a purified adduct.

1       39.      The method of claim 36, further comprising the steps of:  
2                  decanting an organic phase from an aqueous phase, and  
3                  distilling the adduct to form a purified adduct.

1       40.     The method of claim 36, wherein the amine is selected from the group consisting of: (1)  
2       disubstituted or secondary amines where one of the substituents has at least three carbon atoms; (2)  
3       primary amines having a sterically bulky group including, without limitation, di-substituted methyl  
4       groups, tri-substituted methyl groups, aralkyl groups, aryl groups, alkaryl groups, other bulky groups  
5       or mixtures or combinations thereof; (3) diamines having a sterically bulky group including, without  
6       limitation, di-substituted methyl groups, tri-substituted methyl groups, aralkyl groups, aryl groups,  
7       alkaryl groups, other bulky groups or mixtures or combinations thereof; and (4) mixtures or  
8       combinations thereof, where the substituents can have one or more of the carbon atoms replaced by  
9       oxygen atoms in the form of ether moieties and/or nitrogen-containing groups in the form of tertiary  
10      amine or amide moieties and/or one or more of the hydrogen atoms replaced by fluorine atoms  
11      and/or chlorine atoms.

1       41.     The method of claim 36, wherein the amine is selected from the group consisting of  
2       dialkylamines mixed dialkylamines, aryl amines, alkylaryl amines, diaryl amines, dialkaryl amines,  
3       diaralkylamines, dicycloalkylamines, mixed cycloalkylamines, alkycycloalkylamines,  
4       aryl cycloalkylamines, bis(dimethylamino-alkyl)amines, bis(aminoalkyl or  
5       aminocycloalkyl)methanes, bis(aminoaryl)methanes, ring system including an external primary or

6 an internal or external secondary amine, and mixtures or combinations thereof.

1       42. The method of claim 41, wherein the amine is selected from the group consisting of  
2 dipropylamine, diisopropylamine, dibutylamine, diisobutylamine, di-tertbutylamine, dipentylamine,  
3 diisopentylamine, dineopentylamine, dihexylamines, diheptylamine, dioctylamines, dinonylamine,  
4 didecylamine, diadamanylamine, butyl-propylamines, butyl-hexylamines, butyl-heptylamines, hexyl-  
5 heptylamines, aniline, substituted analogs thereof, naphthyl amine, substituted analogs thereof,  
6 diphenyl amine, dinaphthylamine, substituted analogs thereof, bis(monomethyphenyl)amine,  
7 bis(dimethylphenyl)amine, bis(trimethylphenyl)amine, dicyclopentylamine, dicyclohexylamine,  
8 dicyclooctylamine, N-cyclopentyl,N-cyclohexylamine, tetramethylamino bis-propylamine  
9 (((CH<sub>3</sub>)<sub>2</sub>NCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>)<sub>2</sub>NH), bis(4-aminocyclohexyl)methane, bis(4-aminophenyl)methane, 1,8-  
10 diazabicyclo[5.4.0]undec-7-ene and bispicoylamine and mixture or combinations thereof.

1       43. The method of claim 36, wherein the aldehydes is a compound having the formula R-CHO,  
2 where R is H or a carbon-containing group having between 1 and about 20 carbon atoms, where one  
3 or more of the carbon atoms can be replace by oxygen atoms in the form of ether moieties, nitrogen  
4 groups in the form a tertiary amine or amide moieties, or mixtures or combinations thereof and  
5 where one or more of hydrogen atoms can be replace by fluorine atom, chlorine atoms or mixtures  
6 or combinations thereof.

1       44. The method of claim 43, wherein R is H or a carbon-containing group having between 1 and  
2 about 10 carbon atoms.

1       45. The method of claim 36, wherein the aldehyde is selected from the group consisting of  
2 formaldehyde or a formaldehyde donor, an alklyaldehyde or an alklyaldehyde donor, an arylaldehyde  
3 or an arylaldehyde donor, a methoxyaldehyde or a methoxyaldehyde donor, an hydroxyaldehyde or  
4 an hydroxyaldehyde donor, an aldol condensate and mixture of combinations thereof.

1       46. The method of claim 36, wherein the aldehyde is selected from the group consisting of  
2 formaldehyde, acetaldehyde, cinnaminaldehyde, glyceraldehydes, vanillin, veratraldehyde, alloxan,  
3 noneal, 1-formyl piperidine, salicylaldehyde, citronella, and mixtures or combinations thereof.

1       47. The method of claim 36, wherein the aldehyde is from an aldehyde donor selected from the  
2 group consisting of inhibited or non-inhibited paraformylaldehyde, methyl formal, acetaldehyde,  
3 paraldehyde (trimer of acetaldehyde), glycolaldehyde, glyceraldehyde, hydroxymethyl  
4 glyceraldehyde, butyl formal, trioxane, tetroxane, glyoxal, methyl formcel (a hemi-acetal, 55 percent  
5 formaldehyde solution in methanol and methoxy-methanol or water), hydantoin,  
6 hexamethylenetetramine, hexamethylolmelamine, 2-[(hydroxymethyl)amino]ethanol, 5,5-  
7 dimethylhydantoin, tris(hydroxymethyl)nitromethane, 2-nitro-2-methyl-1-propanol, 2-nitro-2-ethyl-  
8 1,3-propanediol, 2-nitro-1-butanol, and acetaldehyde ammonia and mixtures or combinations thereof.

1       48. A sulfur scavenging composition comprising a reaction product of at least one sterically  
2       hindered primary or secondary amine and a molar excess of at least one aldehyde, under conditions  
3       to produce substantially monomeric aldehyd<sup>e</sup>-amine adducts.

1       49. The composition of claim 48, wherein the adducts is a compound of formulas (I), (II) or  
2       mixtures thereof:



where R is a hydrogen atom (H) or a carbon-containing group, R<sup>1</sup> and R<sup>2</sup> are the same or different, at least one being a sterically hindered carbon-containing group having between about 3 and about 24 carbon atoms or R<sup>1</sup> and R<sup>2</sup> can form a ring system, R<sup>3</sup> is a divalent sterically hindered carbon-containing group, R<sup>4</sup> and R<sup>5</sup> are the same or different and are H or a CH<sub>2</sub>R group and where one or more of the carbon atoms of R, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> or mixtures thereof can be replaced by oxygen atoms in the form of ether moieties, nitrogen groups in the form of tertiary amines or amide moieties or mixtures thereof, and where one or more hydrogen atoms of R, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> or mixtures thereof can be replaced by fluorine atoms, chlorine atoms or mixtures thereof.

1       50. The composition of claim 49, wherein R<sup>1</sup> and R<sup>2</sup> are the same or different sterically hindered  
2       carbon-containing groups.

1       51. The composition of claim 49, wherein R is H.

1       52. The composition of claim 49, wherein R is selected from the group an alkyl group, an aryl  
2       group, an alkaryl group, an aralkyl group and mixtures or combinations thereof.

1       53. The composition of claim 49, wherein R is H and R<sup>1</sup> and R<sup>2</sup> are the same or different and are  
2       selected from the group consisting of diisobutylamine, dipentylamine, diisopentylamine, dineopentyl  
3       amine, diadamanylamine, diphenyl amine, dicyclopentylamine, dicyclohexylamine,  
4       tetramethylamino bis-propylamine (((CH<sub>3</sub>)<sub>2</sub>NCH<sub>2</sub>CH<sub>2</sub>CH<sub>2</sub>)<sub>2</sub>NH), bis(4-aminocyclohexyl)methane,  
5       bis(4-aminophenyl)methane, 1,8-diazabicyclo[5.4.0]undec-7-ene, bispicoylamine and mixtures or  
6       combinations thereof.

1       54. The composition of claim 48, wherein the composition comprises a solution including from  
2       about 5 wt.% to about 50 wt.% of the adducts the remainder being a solvent

1       55. The composition of claim 49, wherein the composition comprises a solution including from  
2       about 5 wt.% to about 50 wt.% of the adducts the remainder being a solvent

1       56. The composition of claim 48, wherein the adducts is a compound of formulas (IA), (IIA) or  
2       mixtures or combinations thereof:



5       where R is H or a carbon-containing group, R<sup>1</sup> and R<sup>2</sup> are the same or different sterically hindered  
6       carbon-containing groups having between about 3 and about 24 carbon atoms or R<sup>1</sup> and R<sup>2</sup> can form  
7       a ring system, R<sup>3</sup> is a previously defined, R<sup>4</sup> and R<sup>5</sup> are CH<sub>2</sub>R, and where one or more of the carbon  
8       atoms of R, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> or mixtures thereof can be replaced by oxygen atoms in the form of  
9       ether moieties, nitrogen groups in the form of tertiary amine or amide moieties or mixtures thereof,  
10      and where one or more hydrogen atoms of R, R<sup>1</sup>, R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup>, R<sup>5</sup> or mixtures thereof can be replaced  
11      by fluorine atoms, chlorine atoms or mixtures thereof. The compositions of the present invention  
12      are generally used as a solution in an appropriate solvent, preferably an organic solvent and  
13      particularly an aprotic organic solvent.

1       57. The composition of claim 56, wherein the composition comprises a solution including from  
2       about 5 wt.% to about 50 wt.% of the adducts the remainder being a solvent

1 58. The composition of claim 48, wherein the adducts is a compound of formulas (II), (III) or  
2 mixtures or combinations thereof:



5 where R is H or a carbon-containing group, R<sup>1</sup>" is a sterically hindered carbon-containing group  
6 having between about 3 and about 24 carbon atoms, R<sup>2</sup>" is H or a CH<sub>2</sub>R group, R<sup>3</sup> is as previously  
7 defined, R<sup>4</sup>" and R<sup>5</sup>" are H and where one or more of the carbon atoms of R, R<sup>1</sup>", R<sup>2</sup>", R<sup>3</sup> or mixtures  
8 thereof can be replaced by oxygen atoms in the form of ether moieties, nitrogen groups in the form  
9 of tertiary amine or amide moieties or mixtures thereof, and where one or more hydrogen atoms of  
10 R, R<sup>1</sup>", R<sup>2</sup>", R<sup>3</sup> or mixtures thereof can be replaced by fluorine atoms, chlorine atoms or mixtures  
11 thereof, and where the amount is sufficient to reduce, reduce below a given value, reduce below  
12 detection limits or substantially eliminate noxious sulfur species from the fluid and where the fluid  
13 includes an organic phase.

1 59. The composition of claim 58, wherein the composition comprises a solution including from  
2 about 5 wt.% to about 50 wt.% of the adducts the remainder being a solvent